DOCUMENT RESUME

ED 119 992 SE 020 390

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TITLE	The Energy Situation. A Two-Week Self-Contained Unit for the Secondary Schools.
INSTITUTION	Del Mod System, Dover, Del.
SPONS AGENCY	National Science Foundation, Washington, D.C.
REPORT NO	NSF-GW-6703
PUB DATE	Jun 75
NOTE	51p.
AVAILABLE FROM	Mr. John F. Reiher, State Supervisor of Science and Environmental Education, Dept. of Public Instruction, John G. Townsend Building, Dover, Delaware 19901 (Free while supply lasts)
EDRS PRICE	MF-$0.83 HC-$3.50 Plus Postage
DESCRIPTORS	Energy; *Energy Conservation; Environmental Education; Instructional Materials; Physical Sciences; Science Course Improvement Project; Science Education; Secondary Education; *Secondary School Science; *Units of Study (Subject Fields)
IDENTIFIERS	*Del Mod System; National Science Foundation; NSF

ABSTRACT

A unit of study is presented in this monograph, intended to be self-sufficient, though teachers are urged to read as much material as possible. Overall objectives are presented. Time allotted is suggested at two weeks. The unit contains ten mini-units, plus class activities, class discussion questions, individual student projects, and possible quiz questions. A bibliography is included in the unit as well as five suggested field trips, possible films with information relating to cost, and place of procurement. Magazines and possible guest speakers are suggested. (EB)

THE ENERGY SITUATION

A TWO-WEEK SELF-CONTAINED UNIT FOR THE SECONDARY SCHOOLS

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June 1975

Printed and disseminated through the office of the Del Mod Component Coordinator for the State Department of Public Instruction, John G. Townsend Building, Dover, Delaware 19901

Preparation of this monograph was supported by the National Science Foundation Grant No. G.W. 6703 to the Del Mod System, P. O. Box 192, Dover, Delaware 19901

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INTRODUCTION TO ENERGY UNIT

We are presenting this unit because we feel that the energy crisis is real. Our lives will be shaped by the way we solve it. We feel that knowledge is the only real basis for making the solution. Hence we have written - after careful research into most of the recently published books, magazines, and newspapers - the most factual and complete summary of materials that we are able to compile.

The unit has been constructed to be self-sufficient, though we would recommend that teachers read as much material as time will allow. We have starred the books in the bibliography that we consider particularly worthwhile.

OVERALL OBJECTIVES

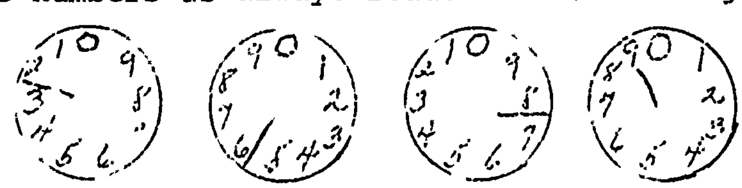
Because there is an energy crisis in our country, our objectives are to give enough factual information for the student:

1. to be convinced that there is an energy crisis
2. to know why and how it has occurred
3. to be presented with information about our present fuels and fuel choices for the future
4. to examine his and his family's energy consumption patterns
5. to begin to act personally and constructively about the energy situation

UNIT CONTENTS

We would suggest that two weeks be allotted for this unit. The unit contains ten mini-units, plus class activities, class discussion questions, individual student projects, and possible quiz questions. We covered approximately one unit per day, though some individual units may take less than and some more than a class period. The order in which they are covered is up to the individual teacher.

One week prior to starting the unit, explain to the students that the kilowatt-hour (KWH) is the accepted unit of energy from the electric company. Electric meters are usually located by back doors or in garages and have four or five circular dials that are read from left to right. Adjacent dials go in opposite directions. Where the indicator is between two numbers, the smaller of the numbers is always read. The following is an example meter:



This would be a reading of 2579 KWH. Students are to read the meter daily for the week preceding the unit. Electricity usage for a day is found by subtracting a day's reading from the following day's reading.

PROJECTS

I. DUE FIRST DAY OF ENERGY UNIT - For the week preceding the energy unit, have students read electric meter each day at approximately the same time of day. This is meant to be a normal week of electricity use. Have students make a drawing of the dials on their meters.

Have students make a list of all electric appliances in their homes.

Have students also read electric meter during first week of unit, after instructing them to conserve energy during this time. They are to compare, with your help, the energy used during the normal week prior to the unit when they were taking daily readings to this week of conservation. (We sent a letter to parents asking for their cooperation with conservation week. The standard of living for this week should still be considered adequate by the family.)

Calculations for you to follow through with class: Multiply each week's use by 52 to find consumption for one year. Make the assumption that each student's family is an average family, and that there are 40 million such families in the U.S.

Multiply each students' yearly use on the basis of each of the weeks by 40 million to find total U.S. usage for year in each case.

Subtract the two numbers to find how many KWH of electricity would be saved in the U.S. if people conserved as they had.

Since there are approximately 2000 KWH per barrel of oil, divide saved KWH by 2000 to get barrels of oil saved. Compare figures around the room.

The average electricity use by D.P. & L. customers is 168 KWH per week. Have students decide if they use above or below the average amount.

You may work through this problem any time during the second week.

Going further, your class might be interested in the energy savings if they drastically cut their energy use. Since it is unrealistic to expect anyone to do this for a long period of time, we asked each student to do this for one day only during the second week and then multiplied the KWH by seven to come up with an approximate weekly amount.

II. DUE SECOND DAY OF ENERGY UNIT - Discuss with your family ways that they are currently trying to save energy. E.g., is your home insulated? If so, how? Do you try to keep your house at a certain temperature?

II. (Continued) -

Do you try to reduce use of lights, appliances, etc.? Do your parents take the bus or belong to carpools? Do you close draperies at night?, etc. Make a list of ways you are trying to save.

III. FIRST ARTICLE DUE END OF FIRST WEEK OF UNIT
SECOND ARTICLE DUE END OF SECOND WEEK OF UNIT

Read two current articles about energy. Summarize each article and comment on it. Articles may come from newspapers or magazines.

IV. The student chooses two projects from the following list. One is due at the end of the first week. The second is due at the end of the second week.

1. Interview someone over seventy. Have them relate to you how energy use has changed since they were children - transportation, heating, the home, the school.

2. Make a collage or other art work expressing the use of energy in our society.

3. Write a poem that could serve as an obituary for the automobile.

4. Check a supermarket, drug store, or variety store for packaging of merchandise. Which packaging is necessary and helpful? Which is unnecessary? Can you find any non-essential or completely wasteful merchandise?

You as a teacher may wish to schedule school or after school trips to the following places. Students can write reports on their trip.

5. Trip to the Solar House at University of Delaware. University will arrange private trips through the house for school groups.

6. Trip to Second Sun or Peachbottom nuclear plants.

7. Trip to Conowingo Dam to observe hydroelectric power.

8. We got a public relations person from Dart - Delaware's mass transit system, to speak. He gave a history of public transportation in Wilmington that was well received by students.

9. We also got two community people - one against atomic power (Sierra Club or Common Cause member), and one for atomic power (D.P.&L. representative) to have a debate.

We had students summarize and comment on the speakers.

10. Read school electric meter for one week and compute daily electricity use. Graph and discuss results.

Other projects that we used, but found to be less successful, are as follows:

1. Survey a number of automobile dealers on the following topics:

    a. Should the U.S. limit horsepower?
    b. Gas mileage
    c. Sales trends of compact cars

2. Have a debate on this topic -

    Resolved. An individual's use of energy can be limited without undue loss of personal freedom.

3. Plan an energy awareness day program for the elementary school. This might include - slides, movies, speakers, contests, displays, posters, activities, puppet shows, etc.

4. Plan a transportation system for your city for the year 2000. What effect will it have on energy use?

5. Keep a record of the garbage your family throws out over a seven day period. Could any of the items have been used again or recycled or have been a source of energy? Discuss.

6. Build a windmill. Discuss it's use and limitations.

7. Describe as fully as you can "the good life," as seen by you.

8. How is the world food supply tied to the energy problem?

9. Do an indepth report on one of our possible energy sources.

10. Some people believe that if energy were just cheap, clean and abundant, the world would be a wonderful place to live in, and all our social ills would be solved. Discuss this viewpoint, considering such things as what effect this would have on population growth, and such books as _Brave New World_ and/or _1984_ .

MINI UNIT #1

OUR PRESENT ENERGY SITUATION - HOW WE GOT HERE

Objectives and possible quiz questions:

Students should be able to answer the following questions:

1. Why has our use of energy more than doubled in the past 20 years?
2. Why have we depended more and more on foreign oil in the past 20 years?
3. Why has the percentage use of coal declined in the past 20 years?
4. What political factors are involved in our present crisis?

Projects due:

Reading the electric meter and making a list of all electric appliances in the home. (Project #I).

Class discussion questions:

1. Are any of the appliances in your home unnecessary?
2. Could you cut down on the use of any of the necessary appliances?
3. What appliances are in your home that were not there 20 years ago?
4. What appliances do you think might be here 20 years from now?

Background material is on following pages.

MINI UNIT #1

OUR PRESENT ENERGY SITUATION - HOW WE GOT HERE

Our nation has been blessed with abundant natural energy resources of wood, coal, oil, and natural gas. We have always been able to obtain these easily and cheaply. Thus our consumption of energy has grown.

Until the 1950's we actually exported more energy commodities than we imported. But the picture has been changing since then.

Since 1950 our total energy use has more than doubled. But our domestic production has not doubled. The reasons for our increased usage of energy include:

1. We pay lower rates when we use more.
2. Promotional advertising for cars, air conditioners, plastics (!), etc. make us all buy more of these.
3. Our expanding highway system encourages more cars and more traveling by car.
4. Subsidies have been given to air travel and trucks, which use more energy than trains.
5. Growth in suburbia, which means we who live there do much more traveling to stores, etc., and use more energy in our homes.
6. Energy has been cheap (the price of energy actually declined in the 1960's) and not a prime consideration in the manufacture of articles.
7. Our food production methods make ever more use of energy- in fertilizers, pesticides, machinery, storage, transportation, etc.

In the 1950's abundant amounts of oil were found in the Middle East. United States companies explored, drilled for, built the necessary equipment, and owned controlling interests in the foreign oil firms. It cost only twenty to thirty cents a barrel to get the oil out of the ground. Not much money was given to the host country. So the oil companies could make a good profit and still sell the oil cheaply. We thought we had a never ending supply.

Oil costs more to produce in our own country than abroad, and therefore we relied more and more on foreign imports. Oil production in this country has actually declined in the past few years. We now import 7,000,000 barrels of oil a day - 1/3 of our total oil consumption.

Coal is our most abundant natural resource, but since 1950 its use has been declining (from 48% to 17% of the market). This means that an ever larger burden must be assumed by oil and gas. Coal use declined for the following reasons:

1. For convenience, people shifted away from coal fired furnaces to those using oil or gas.
2. Coal mining is dangerous, and is a dirty business. Many thousands of miners have been killed and many more have died of black lung disease. There have been new health and safety measures that have made underground mining slower and more expensive. Labor costs have gone up.
3. Trains switched from coal-fired steam engines to oil diesel engines.
4. The Clean Air Act of 1970 made the burning of high-sulfur coal almost impossible. Many utilities changed from coal to oil for production of electricity. Industrial plants also had to shift from coal to oil for the same reason. We became aware of our environment!

Still, few people worried. All that nice, cheap oil was still available from foreign sources.

Natural gas along with oil became ever more popular. The reasons for this popularity are cleanliness, efficiency, convenience, and low cost. However, just as oil exploration in our country was declining, so was exploration for natural gas. There were two main reasons for this:

1. Natural gas is often found with oil, and when oil exploration declined, the associated gas was not found either.
2. The price of natural gas was strictly controlled by the government. Gas companies claim they cannot make enough money from it to look for more. As a result, there is a severe shortage of natural gas this winter. Some people say that there is plenty being stored, just waiting for the price to increase. This would at best be a temporary supply.

As a footnote, it is interesting to note that most of the natural gas associated with the oil wells in the Middle East is just burned off! At present there are very few ships capable of transporting such a cargo. What a waste of a valuable resource!

We suddenly find our source of foreign oil not as available as before or at least so expensive as to cause serious economic problems. The oil companies in the Arab countries and elsewhere have been nationalized. This means that foreigners can decide how much oil we get from them and also how much we pay for it. Prices of oil quadrupled over night. At one point our supply was interrupted by an embargo and this could quite readily happen again.

We also have the political situation in the Middle East to contend with. We are trying to continue our support of Israel and still woo the Arabs. We are trying to maintain peace between them. But the situation is precarious at best.

We have talked, therefore, about becoming more self-sufficient, energy wise. We find that for the present (probably at least ten years) we do not have enough energy to meet our demands. There are not enough oil fields in production, natural gas is in short supply, coal mine production has declined, nuclear plants have been stalled, the Alaskan pipeline is not yet built. It will cost more money to get energy supplies increased. It will take time. In the meantime we have a choice - dependence on foreign oil or CONSERVATION.

MINI UNIT #2

INEFFICIENCIES IN OUR PRESENT SYSTEM

Objectives and possible quiz questions:

Students should be able to complete the following assignment:

Make a list of inefficiencies that exist in the following systems and propose ways of increasing the efficiency of each:

1. Our personal transportation (including the car)
2. Hauling freight
3. Packaging merchandise
4. Disposable items
5. Construction of homes and buildings
6. Construction of appliances such as air conditioners
7. Our personal habits of using appliances, keeping our houses heated, etc.

Students will check their own homes for electricity use savings, heating fuel savings, insulation, family driving habits.

Projects due:

Project #II.

Class discussion questions:

1. What do you do in your home to save on heating fuel and electricity? Could you be doing more than you are? If so, what?
2. What do you think about your own or your family's driving habits?
3. What appliances use the most electricity? (See enclosed booklet from Delmarva Power for this information.)

Background material is on following pages.

MINI UNIT #2

INEFFICIENCIES IN OUR PRESENT SYSTEM

1. The switch from train to truck and air - Trains are much more efficient (up to five times). Trucks have been subsidized (most highways are free) while trains have been taxed. Back in the 1800's exorbitant profits were made on the rails and the federal government has been hard on trains ever since.

2. The United States passenger car - The trend in the past ten years has been for the small car to get heavier - air conditioning, power equipment, etc. Gas mileage is directly related to weight of car. So gas mileage has been going down. Also, pollution controls were railroaded through, decreasing mileage. Cars should emit fewer pollutants, but an overall look at engine design might produce fewer pollutants and better mileage. The internal combustion engine of the car at present is less than 25 percent efficient. More than one third of total oil used in this country goes to gasoline- 6.2 million barrels a day - about the amount we import. If all cars were to get 25 miles per gallon, or about twice the mileage they now get, we could drive the same amount and cut our oil consumption by a fantastic amount - several million barrels of oil a day. The Japanese have already built such cars. Surely our technology can be just as good.

3. Many homes and industrial buildings are built without insulation. Initial costs are less, and as long as energy was cheap, who cared? But much energy was wasted, and now it's expensive, too.

4. Our present electrical generators are only 30% efficient. That means we throw away 70% of the energy. No system is 100% efficient, but there are different kinds of generators. The cost of developing these, as compared with the cost of the (once) cheap fuel, has kept us from utilizing them.

5. Millions of "gadgets" are on the market for the "convenience" of the consumer. Do we really need them all? No-frost refrigerators use approximately twice the electricity of the normal kind.

6. Many products are made so that the initial price to the consumer is low, but the operating cost is high (especially with increase in fuel prices). Air conditioners are an example. By using cheaper parts, the initial cost is lower, but operating expenses are higher - and will continue to increase as cost of energy increases. The government is now forcing manufacturers to print on the air conditioner, when you buy it, what its efficiency is. The higher the efficiency rating of the air conditioner, the less energy it will take to operate it.

7. Some recent buildings have put a single light switch on a floor. That means that any time a person wants to use a single light, every light on the floor must be turned on.

8. Our packaging of goods has become ridiculous - often the packaging is designed to entice the consumer or make him think his item is better than it really is. Then all the excess trappings must just be thrown away, adding to pollution.

9. Throwing away animal wastes and garbage. These cause pollution in rivers and streams. Animal wastes could contribute to fertilizer - about ten percent of what we need. Garbage can be partially recycled and partially burned to generate electricity for a city. In Maine, oysters are being grown on a city's waste, making it a paying proposition.

10. Using disposable bottles and not recycling. Using disposable diapers. Cheaply constructed merchandise, so that it falls apart in a short time.

11. Making us think that we need ever increasing amounts of everything just to be happy and that it is our "right" to use as much of anything as we wish or can pay for.

12. Highly processing our food.

13. Use of heat pumps for industry. These are refrigerators or air conditioners operated in reverse. They warm the house by cooling the out of doors. You get two to three times as much heat energy as with conventional heaters. The heat pumps have been used to date in the South, but might be expanded to other regions.

14. Keeping our houses too hot - bad for health - and driving too much. Personal habits of not turning off lights, not using storm windows, not weatherstripping, etc.

15. Throwing away heat - from electric plants. It now pollutes streams. Smaller electric units in a residential complex could use the waste heat for heating the residential units.

Most of the inefficiencies mentioned are due only to our wasteful habits and with our showing off our affluence. These can be changed immediately, using existing technologies, and being more conscious of our own ways of living.

Several inefficiencies (notably generation of electricity, 30 percent efficient, and the diesel engine for cars, 25 percent efficient) have to do with the mechanical structure of the machine. To date, technology does not exist to remedy these and the matter is controversial. Some people believe that increasing the efficiencies of these machines can be accomplished through research and is the hope of the future.

For example, if the efficiency of each were doubled, we could have twice as much energy from each without using any more fuel.

However, other people point out that there is a limit to the efficiency of any system, and they feel we have neared that limit. In the past fifty years, we have already greatly improved the efficiency of each system, and have reached the limits of the system. To make an electric generator run more efficiently, the temperature of the steam must be higher and the return water cooler. Yet it takes energy to increase the temperature of the steam and cool the water, and therefore you put in about as much energy as you gain in efficiency.

It is obvious, though, that even if mechanical efficiencies cannot be improved, we have much we can do to improve the overall efficiency of our whole life style - without sacrificing our standard of living. It will take awareness and thoughtfulness and willingness on our parts. I hope we are up to the challenge!

MINI UNIT #3

WHAT FUELS DO WE USE?

Objectives and possible quiz questions.

Students should be able to answer the following questions:

1. What percentage of the world's total energy production does the United States consume?
2. What fuels do we use?
3. How has their growth developed up until now?
4. For what do we use our energy?
5. How efficient is our energy use?

Projects due:

Any chosen by the teacher.

Class discussion question:

Is it fair for a citizen of the United States to use six times as much energy as the average world citizen? Why or why not?

Background material is on the following pages.

Charts A, B, and C from Understanding The National Energy Dilemma are useful to post during this Mini Unit. See bibliography.

WHAT FUELS DO WE USE?

The United States in 1972 consumed more than one third of the world's total energy production, while having only about one sixteenth of the world's population. We in the United States are fortunate to have many energy sources - coal, oil, gas, nuclear, geothermal, and hydroelectric power. This energy is used for residential and commercial establishments, industry, and transportation. All of these sources and uses have had varying growths and efficienies. Let us examine them.

The overall trend in fuels has been from wood to coal to oil to gas to nuclear energy sources. Three of these arc often termed the fossil fuels. These are coal, oil, and natural gas. The use of wood as a fuel has dwindled because of its scarcity and its use in construction and furniture.

By 1850, coal was the primary fuel for transportation and industry in the United States, and, by 1900, coal was the most predominant source of home fuel. Today the use of coal is almost completely tied to the electrical utilities. During the time period 1950-1970, the use of coal in the United States decreased. Since 1970 it has increased and should continue to do so.

By 1910, oil was our number one refinery product and energy source on the transportation and industrial scene. There were several reasons for this. It was found that oil could fire a boiler as well as coal. The rise of the automobile increased the need for gasoline - one of the products of refining crude oil. Also oil production shifted to areas of the country where coal was scarce, such as Texas, Oklahoma, and California. By the late 1920's gasoline was the number one refinery product and the rapid expansion of oil for domestic use and generating electricity has enabled the production of crude oil in the United States to grow at a rapid rate. It is still doing so today.

As natural gas and oil often occur together under the earth's surface, one would think that the use of natural gas for the energy consumer would parallel the use of oil for this purpose. It did not. For fifty years of oil production we allowed the natural gas to escape and did not put it to work for us. By the late 1920's a network of pipes was laid to many sections of the country and the use of natural gas for energy and home heating has been on the increase ever since. It should be noted here that the transportation problems that plagued the United States for many years is currently a world problem in that many nations do not know how to store and transport all the gas they are currently just burning off at the well site.

Nuclear energy is a much more recent source of fuel for us as compared to the fossil fuels. Nuclear energy has been on the increase of late and several fission reactors have been built. A nuclear power plant is very similar to a fossil fuel plant as only the primary source of energy differs. In both systems the heat from the energy source usually produces steam to turn a turbine to drive a generator to set up a current of electricity. The first nuclear power plant began operating in the U.S.S.R. in 1954. The first United States plant was built in Shippingport, Pennsylvania, in 1957. By 1970 the United States had about nineteen plants representing approximately two percent of our country's electric utility capacity. Over one hundred plants are now under construction or planned; therefore the use of nuclear energy for power is still increasing.

In 1904 in Larderollo, Italy, geothermal energy was first used for production of electricity from a dry steam field. The first electric power plant to use a hot water reservoir was built in New Zealand in 1946. Using geothermal energy for electricity is a recent idea in the United States and has not been used extensively as yet.

Hydroelectric power is an old energy source in this country and in the world - more than 2000 years ago man began to build watersheds. About fifteen percent of the electricity used in the United States is supplied by hydroelectric plants.

Where does all the energy go - no matter what the source? The three major areas of energy use are household and commercial, transportation, and industry. All of these areas are using more and more energy all the time. Industrial use is the largest with the metal and chemical industries being the prime users. The second largest category of energy use is transportation with automobiles contributing to over half of this use. Space heating uses over half of the energy of commercial and residential establishments. Other uses in this area are water heating, refrigeration, cooking, air conditioning, television, food freezing, clothes drying, and lighting. In this twentieth century energy use in these various areas has doubled about four times.

How efficient is our use of all this energy? Unbelievably perhaps, the incandescent light bulb is only about five percent efficient. This means that only about five percent of the electricity used is converted into visible light. The internal combustion engine is about twenty-five percent efficient, up from approximately twenty-one percent in the 1920's. We do not seem to be very efficient in our energy use and the road to more efficient energy use is a difficult one. Oil and gas furnaces are about seventy-five percent efficient - twice as efficient as the electric resistance heaters currently being installed in many new housing developments. Both wise purchasing by the consumer and more research in the area of efficiency can help to make our increasing energy use more productive.

MINI UNIT #4

WHERE DO WE GET OUR FUELS?

Objectives and possible quiz questions:

Students should be able to complete the following assignment:

1. How fast are we using our fuels?
2. What is the difference between a resource and a reserve?
3. What reserves do we have?
4. Where are world supplies located?
5. Where do we get our energy resources?
6. What is the finiteness of the world's resources?

Projects due:

Any chosen by the teacher.

Class discussion questions:

1. What effect has the OPEC union had on the United States?
2. Are we self-sufficient in our energy use at this time?
3. How do you feel about off-shore drilling for more oil?

Background material is on following pages.

WHERE DO WE GET OUR FUELS?

We in the United States are using fossil fuels at a rate more than one hundred thousand times as fast as nature can replace them. Until the late 1940's,the United States was a net exporter of energy, including oil. Since that time we have become increasingly dependent upon foreign oil. At the present time we import about thirty-eight percent of the oil we use. We are the largest coal exporter in the world. However, the energy value of these coal exports is only about one-fourth that of our oil imports.

In discussing our fuels both in the United States and in the world, it is important to differentiate between a resource and a reserve. A resource generally refers to how much of the given fuel is thought to exist. A reserve, on the other hand, indicates how much of that fuel is estimated to be recoverable. Thus it is more important to consider our reserves than our total resources as all resources are not recoverable. For example, our coal reserves are about one-seventh of our coal resources. Our oil and gas reserves are only about one-thirtieth of our resources of oil and gas with present technology.

The world distribution for coal shows that the U.S.S.R. has about three-fifths,the U.S. one-fifth, and the rest of the world the remaining fifth. The petroleum distribution is quite different from this. The Middle East has more than one-fourth of the world's oil, with the U.S.S.R. and China running a close second with just less than one-quarter. Africa has one-eighth of the oil, as do Canada and Latin America combined. The U.S. has less than one-eighth of the petroleum, as do all the rest of the countries of the world combined. The world itself is about ninety-percent coal and less than ten percent gas and oil. However, our energy reliance since 1950 has been on oil, even though the United States does not have the bulk of the supply by far and even though the earth itself can supply us with much more coal than oil.

Since 1950 we have more than doubled our energy demand in this country. To meet this demand we found that it was cheaper to import oil from the Middle East than to produce more coal of our own. Coal also was not a clean method of heating and did cause pollution problems. This reliance on the Middle East did not seem to be a bad thing, as the energy was both inexpensive and plentiful. Then in the 1960's the Organization of Petroleum Exporting Countries, hereafter called OPEC, was formed to try to stop the economic power of the international oil companies, most of which are United States' companies. The OPEC countries have raised drastically, even quadrupled, the price of oil. In the winter of 1973-74, the Middle East held an embargo against us. What does this mean to us? Do we in the United States depend on OPEC oil?

In looking at the world distribution of oil, it seems apparent that at the present time we do need to rely on foreign oil, unless serious conservation measures are adhered to by the people of the United States. The embargo of last winter affected only ten percent of our energy. The OPEC countries are now so well organized that future embargos would reduce our energy supply by thirty-eight percent - thus a much more serious situation. Our increased energy demand caused us to depend on the OPEC countries. Perhaps the bright side of last winter's embargo is the fact that now we do realize that dependency and are investigating what we can do about it, both in researching new energy sources and in importing oil from countries other than the OPEC countries until we are self-sufficient. In January, 1975 the United States government announced it was now permitting purchase of oil from the U.S.S.R. on a large scale. It should also be mentioned here that our importing fuel disturbs our import-export financial balance and is one of the prime causes of our current inflation and recession.

If we do not increase our rate of using our energy sources at all, our oil and gas will probably last 200 years and our coal 300 years. If we continue to increase our rate of energy use at the same rate as we have the past twenty years, these numbers change considerably to fifty years for oil and gas and one hundred years for coal. United States' resources of uranium for fission nuclear reactors are sufficient to last fifty years. Thus the problem is one of our lifetime and one we must do something about. We are not self-sufficient and our supplies are not long-lasting. We do need research and conservation.

MINI UNIT #5

THE FOSSIL FUELS

Objectives and possible quiz questions:

Students should be able to answer the following questions:

1. Which fuels are the fossil fuels?
2. What are two ways in which coal can be mined?
3. Is using high sulfur coal for generating electricity a problem?
4. How is oil made?
5. How is oil drilled and shipped?
6. What processes does crude oil go through to become the desired end product?
7. What are three uses of oil?
8. How is natural gas recovered?
9. Why is natural gas being burned off at oil wells?
10. What is natural gas used for?

Projects due:

Any chosen by the teacher. First article and first optional project could be due at this time.

Class discussion questions:

1. Would having less oil have an effect on our lives besides having less gasoline and home heating fuel?
2. If the cost of a barrel of crude oil is raised, what other items will then have a higher cost?
3. How should our energy be distributed throughout our country?

Background material is on following pages.

THE FILMS ON COAL, OIL, AND NATURAL GAS LISTED IN THE APPENDIX ARE EXCELLENT AND CAN BE USED TO SUPPLEMENT THIS MINI-UNIT.

DO TOUR A LOCAL REFINERY AND/OR GET SAMPLES OF CRUDE OIL PRODUCTS FROM ONE TO SHOW STUDENTS.

THE FOSSIL FUELS

The fossil fuels are coal, oil, and gas. In this mini unit we shall give background on all three. However, most of our emphasis will be on oil as it plays such a large role in our energy and economy of today.

Coal has been used as an energy source for centuries. As far back as the ninth century "sea coales" from the rocky shores of England were used for cooking and for comfort. In Europe fuel wood became in scarce supply and coal mines began to crop up in many countries. By 1850 shortages of wood in the United States enabled coal to become our foremost fuel for both industry and transportation, while wood was still used for home heating and cooking. Finally by 1900 coal also was used in the home as it was for many years. Today few homes use coal for heating and cooking directly. The use of coal is now almost completely tied to the electrical utilities.

Coal can be mined in two ways. The first way was to dig deep mines in the earth and have men go down in these mines to retrieve the coal. This is extremely dangerous work and is not healthy, as many miners were stricken with black lung disease. Many of these mines are now closed as our need for coal until recently had slackened off. The current method for mining coal is very productive and is safe for the workers. This method is called strip mining and makes use of explosives. This has been done in West Virginia and is planned for Montana. The major negative effect of strip mining is that it destroys the environment. It is hoped that laws will be passed and enforced that will require those corporations which strip mine to have the land returned to its previous state of growth and wildlife within twenty years after the mining has occurred.

Coal is used as a fuel source for electricity throughout the world and in Delaware. High sulfur coal, however, causes many pollution problems and ways to overcome this problem are being researched. Other research is also being done to change coal into oil and gas.

The quest for oil was originally sparked by a growing scarcity of whale oil and other illuminents. Kerosene was in high demand. Throughout the nineteenth century our problem here in the United States was the opposite of our problem today as far as oil is concerned. Ironically, the problem then was overproduction of oil and a struggle to find new uses for a product that could hardly be given away. In the 1900's this pattern changed and by 1910 oil was the top refinery product. Since that time the demand for oil has continually increased for domestic use, for generating electricity, and particularly for gasoline for the automobile.

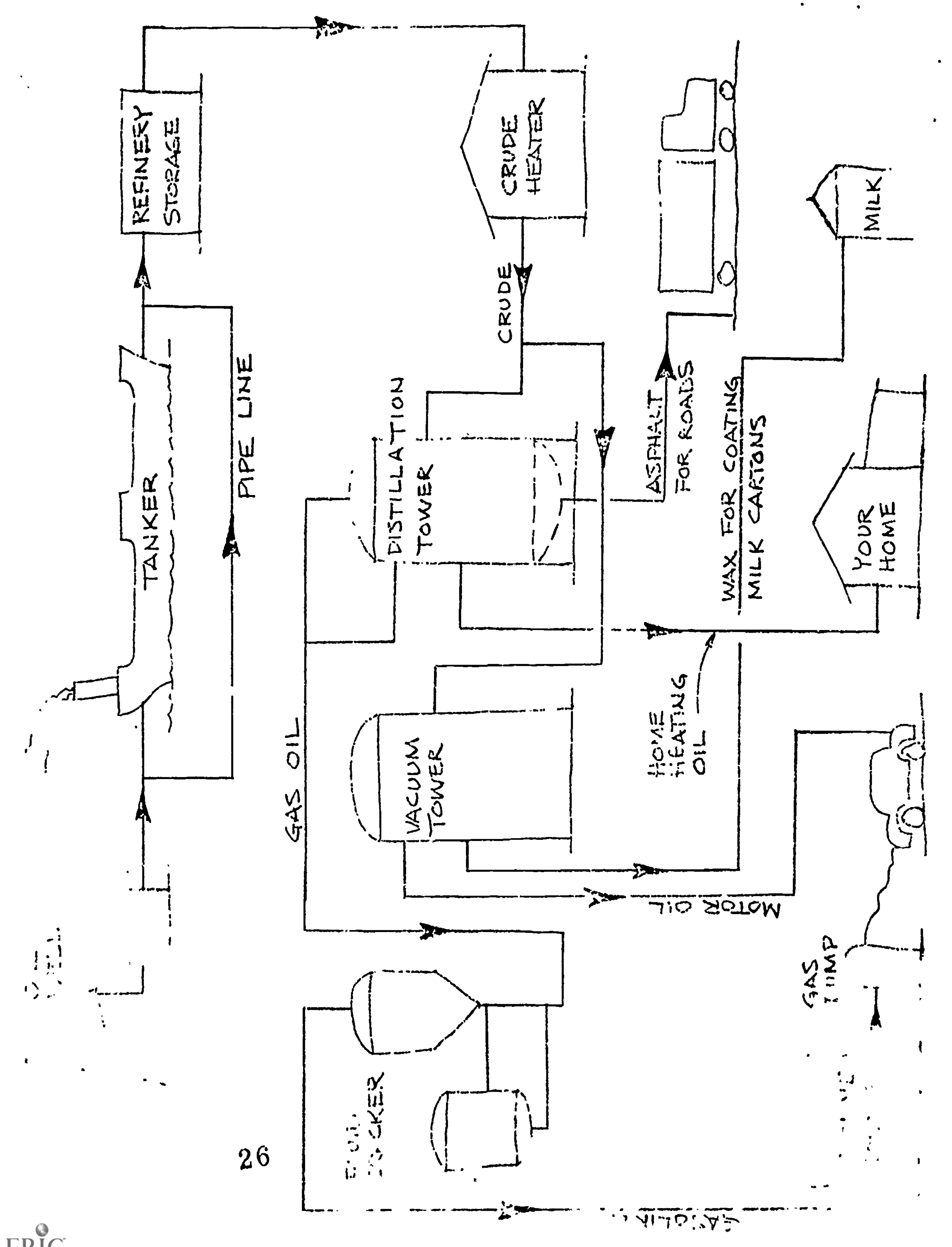
How does nature produce oil? Five hundred million years ago plants and animals lived in oxygenated waters. When they died their corpses settled into the bottom mud of the waterbed and here, anaerobic decomposers fed on them. This left behind a residue of hydrocarbons. Continuing accumulation of the sediments increased the temperature and pressure in the layers below and caused the molecules to rearrange themselves, yielding petroleum. Early stages of this formation are still evident in the Black Sea and the Gulf of Mexico. However, we are using up our oil at a rate 100,000 times faster than nature can replenish it.

The sediments where oil is formed contain both oil and water. If more gas is present than the liquid petroleum can hold in solution, it bubbles to the top and forms a layer of gas. Thus, when oil is found, a layer of water and a layer of gas are usually also found. Oil and gas can escape naturally from the earth and both have been used by many peoples over at least the last 5000 years when the Sumerians actually had asphalt roads for their chariots.

The story of oil production is one of drilling wells to deeper and deeper depths where geologists have reason to believe there is oil because of the geological formation of the earth. The modern oil industry began in 1848 when drillers called "wildcatters" looking for water found oil instead. Modern wells can be as deep as five miles and drilling is carefully planned to take advantage of the reservoir pressure safely. The efficiency rate of recovering the oil used to be only about twenty-five percent. Due to modern technology, this amount of recoverable oil has reached about forty percent. The Alaskan pipeline and offshore drilling should enhance our oil supply, but it must be noted here that oil is an exhaustible resource.

Shale oil is also a future source of an immense amount of oil - some say four times as much as the Alaskan deposits. This oil held in oil shale could possibly be a future source of dyes, drugs, synthetic rubber and fibers, fertilizers, paint, and detergents. Many feel that using shale oil for electricity is not feasible because of the cost involved.

Once the oil is drilled it is shipped via tanker or pipeline to a refinery. Here the crude oil goes through many processes such as distillation and cracking to yield the many products we use so widely today. Some of these products are gasoline, transmission fluid, paraffin, records, tapes, the fibers in permanent press clothing, and many others. The following chart shows the route of oil from the well to the final product: (It should also be noted here that local refineries will loan or give schools samples of crude oil products and also have tours of their facility available.)


REFINERY
STORAGE
CRUDE
HEATER
TANKER
PIPE LINE
CRUDE
DISTILLATION
TOWER
ASPHALT
FOR ROADS
WAX FOR COATING
MILK CARTONS
MILK
YOUR
HOME
GAS OIL
VACUUM
TOWER
HOME
HEATING
OIL
MOTOR OIL
GAS
PUMP

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Oil spills are a definite hazard to the environment and are difficult to clean up. Off-shore drilling is responsible for a negligible amount of these spills. Other sources of spills are the refineries themselves, leaks in pipelines, and oil tankers. The oil tankers are the greatest problem here and create five times the spills as the other sources. This involves accidental spills plus the disposal of oil from the boiler and engine rooms and disposal of wastes from the cargo. Problems as to the responsibility for the clean-up also arise as the owner of the tanker, the owner of the oil and the port involved each feel it is another's responsibility. Another problem is the fact that only four U.S. ports can handle the super tankers at the present time.

Once the oil reaches the refinery, half of it goes to the production of gasoline and another quarter to the production of distillate oils. Perhaps food for thought as to the oil section of the energy crisis is this - if we all walked or bicycled to destinations within three miles of our homes, we would cut our gasoline consumption in half. Think what this would do to our oil needs and thus the amount of time our oil supplies would be useful to us. Think also how much more self-reliant we would be energy-wise and how much less money would be leaving our economy for the Middle East or the U.S.S.R.

Natural gas has a fairly recent history as far as energy consumers are concerned. Natural gas and oil often occur together. Therefore finding new oil fields usually has the bonus of yielding more natural gas. However, for many years we did not know what to do with the natural gas and just let it escape and burn off. Because of transportation problems, the Middle East is burning off much of their natural gas at this time. Natural gas is used for heating and is twice as efficient at doing this than electric heat is.

Natural gas fields are found in the United States with a "wildcatter" finding one as recently as January, 1975, in Texas. There exists a problem in the United States as to who should get the gas for heating and cooking - those that live in the area nearby or those over a thousand miles away who get this gas via pipeline. The people of Monroe, Louisiana, went cold during the Arab oil embargo. The natural gas from their field was piped to Long Island. The people of Monroe have off-shore drilling and feel their needs should be supplied. They also feel that the eastern states should drill offshore to fulfill their own needs. Many people do not want off-shore drilling. This situation is currently one of concern in our country. How do you feel about it?

MINI UNIT #6

OUR ENERGY USE GROWTH RATE AND ITS IMPLICATIONS

Objectives and possible quiz questions:

Students should be able to answer the following questions:

1. How much energy do we use in comparison with the other peoples of the world?
2. At what rate have we been increasing our energy use?
3. What is our projected energy use?
4. What are the implications of this growth rate? Are there limits?
5. What is exponential growth?
6. Are the energy growth rate, food usage growth rate, population boom, etc., related?

Projects due:

Any chosen by the teacher.

Class discussion questions:

1. Can we continue to use energy at our current rate?
2. How are we being limited?
3. Discuss the life in your local community if our energy supply was cut in half. Do not forget the implications of this, i.e. you need to create jobs for resulting unemployed.

Background material is on following pages.

THE BOOK LIMITS TO GROWTH LISTED IN THE APPENDIX IS A GOOD SOURCE FOR THIS MINI UNIT.

CHARTS C, D, AND E UNDERSTANDING THE NATIONAL ENERGY DILEMMA LISTED IN THE APPENDIX ARE USEFUL HERE TO ILLUSTRATE OUR PREDICTIONS FOR FUTURE ENERGY USE.

OUR ENERGY GROWTH RATE AND ITS IMPLICATIONS

The United States has about one sixteenth of the world's population, yet uses one third of the world's energy. Perhaps even more disturbing is the fact that one third of the world's population (including the U.S., U.S.S.R., Canada, Japan, and Europe) uses about eighty-five percent of the world's energy, while the remaining two thirds of the population of the world only uses fifteen percent of the energy.

Energy use in the United States is not now even at its peak. Demand is continuing to grow. By 1990 imported oil usage will increase fivefold, coal usage will double, and imported gas will increase tenfold. Fission reactors will expand to equal coal and gas in their productivity. We have said that these fuels are depletable and may only last fifty years. Why do they suddenly seem to be running out? Has our demand been increasing that much? Will it continue to do so with what effects? Can we do something about it?

In the use of any depletable resource, the time period of discovery and development shows little increase in usage. However, after this the curve of rapidly expanding use goes up very quickly to a peak. After this point the usage must drop off, as the source becomes in scarce supply and the costs extremely high. We are now currently approaching that peak or, perhaps, are at it.

Our energy demand has increased about eighteen fold in the last century and in our own lifetimes the use of energy has been raising at a rate of greater than four percent per year. The world's energy use has been increasing at an even greater rate - about six percent per year. In the United States since 1950, our population has increased by about ten percent, residential energy use by about fifty percent, and the country's total energy use by one hundred percent (has doubled). With a relatively small population increase, why would residential energy use increase so much? A few answers are that all homes now (and did not in the past) have central heating, a hot water heater,a stove, a refrigerator, electric lights, a radio, and a television. Most homes today have a washing machine and many air conditioning. Just since 1969 the number of homes with air conditioning has tripled. Dishwashers have increased fourfold in the same period. Many homeowners purchase frostfree refrigerators and color televisions which both use more energy than their earlier counterparts - manual defrost refrigerators and black and white television sets. Transportation energy use (more cars) has grown at a rate of about four percent per year and the average for manufacturing as a whole is about eight percent per year, with some industrial firms using eleven percent more per year. Obviously our energy usage has been increasing and we have had a role in this.

Perhaps more alarming is the fact that this increase in energy demand is projected to continue. A most serious aspect of our projected energy usage is the fact that we have been, are now having, and will have rapid growth in this and other areas if we do not conserve starting now. This growth has been exponential. What does exponential growth mean? Is there a limit to exponential growth?

Which situation would you rather have - your father giving you a dollar a day for a month, or your father giving you a penny the first day and doubling the amount received each day thereafter? The first situation would give you $30.00 and the second situation would give you over $5,363,709 dollars. Most people would prefer the second situation - a good example of exponential growth. Try to calculate it yourself. The first ten days find you with only $5.12 and perhaps wishing you had taken the dollar a day. However, from this point on, your money doubles at an astonishing, or, if you are considering energy usage, alarming, rate. A quantity exhibits exponential growth when it increases by a constant percentage of the whole in a constant time period - like your savings account or like our increase of six percent per year in energy usage.

Let us use another example of exponential growth to show us how fast our energy usage can peak and how limited we really are in our fuel supply if we continue to demand energy as we have been since 1950. This French riddle illustrates the apparent suddenness with which exponential growth approaches a fixed limit - a limit to rapid growth. This is described more fully in the book Limits To Growth listed in the appendix. Suppose you own a pond on which one water lily is growing. This lily plant doubles in size each day. If the lily were allowed to grow at its own rate without stopping it, it would cover the entire pond in thirty days, thus choking off other life in the pond. For many days the plant seems small and you decide not to worry about it - until it covers half of the pond. On what day will that be? How many days will you have to find a solution to your problem? You were correct if you answered the twenty-ninth day. On that day the pond would be half-covered and you would have only one day to rectify the situation. However, would you realize this or on the twenty-ninth day would you just look out and think that you have plenty of time? This shows us that exponential growth does have a limit and the end does come upon us quickly. We have used energy for years without thought. Now we must act quickly to save ourselves - to conserve and not let the other guy take the responsibility for getting us out of this crisis.

The exponential growth of energy usage is made more complicated by the fact that the world population growth, food usage, production of nuclear wastes, and other phenomena are also growing exponentially and each of these problems affects the other. Therefore our energy situation is related to the food problem and the economic problem. We must act now to gain control of and solve these problems as there is a limit to our growth.

MINI UNIT #7

RADIATION, FISSION, AND FUSION

Objectives and possible quiz questions:

Students should be able to answer the following questions:

1. What are alpha and beta particles and gamma rays?
2. What are nuclear reactions?
3. What is fission?
4. What is critical size?
5. What is a chain reaction?
6. What are the hazards of Plutonium?
7. What are breeder reactors?
8. What is fusion?
9. What are some advantages of using nuclear reactors for electricity? What are some disadvantages?

Class Discussion Questions:

1. Compare and discuss the positive and negative apsects of fission versus fusion.
2. Plutonium can give us much electrical power. Is this power worth the drawbacks that Plutonium has for us as individuals and as a society?

Background material is on following pages.

THERE ARE MANY CURRENT MAGAZINE ARTICLES AND TELEVISION SHOWS ON THIS TOPIC. "THE FAUSTIAN BARGAIN" AND OTHER ARTICLES WILL GIVE YOU GOOD BACKGROUND AND HELP STIMULATE CLASSROOM DISCUSSION.

DURING THIS MINI UNIT IT WOULD BE EXCELLENT FOR THE TEACHER TO CALL THE SIERRA CLUB AND DELMARVA POWER TO ARRANGE FOR SPEAKERS TO COME AND DEBATE BEFORE THE STUDENTS. THIS COULD BE DONE AFTER SCHOOL AS A PROJECT SO THAT ALL STUDENTS COULD BE PRESENT FOR ONE DEBATE.

TOURS MAY BE ARRANGED FOR STUDENTS AT THE SECOND SUN AND PEACH-BOTTOM NUCLEAR REACTORS. SEE APPENDIX.

RADIATION, FISSION, AND FUSION

In 1896 Becquerel, a French physicist, observed that the salts of U (Uranium) affected photographic plates even when the plates were surrounded by black paper and glass and placed in a drawer out of reach of sunlight. Students can do this lab themselves - see Introductory Physical Science Lab. 7.1. Becquerel reasoned from this experiment that the U was emitting unknown particles that possessed great penetrating power.

Just two years later Pierre and Marie Curie discovered polonium and radium in pitchblende. They had felt that there was a reason that the pitchblende gave off more radiation than U should and suspected that other elements must also have this unique property. In discovering these two radioactive elements they established that certain elements emit some form of ray or particle. Work was then started to identify and characterize these rays.

Rutherford found that there are three types of radiation emanating from radioactive substances - alpha particles, beta particles, and gamma rays. These originate in the nuclei of the radioactive atoms.

Alpha particles are positively charged and have two protons and two neutrons like the nucleus of a helium atom. Their penetrating power is slight as paper can stop alpha particles.

Beta particles are negatively charged, have less mass than alpha particles, and are electrons moving at a velocity that approaches the speed of light - 186,000 miles per second. They have a higher penetrating power than alpha particles.

Gamma rays possess no charge and are generally associated with the emission of alpha and beta particles from the nuclei of radioactive elements. Gamma rays are waves, not particles, and travel at the speed of light. They have a far greater penetrating power than alpha or beta particles and can pass through as much as ten inches of lead.

Rutherford and Soddy investigated the fate of a radioactive nucleus in 1902. This investigation led to th theory of nuclear disintegration that radioactive atoms are continually changing into atoms that are similar to the atoms of other elements in a definite disintegration series.

Natural radiation is a spontaneous process over which man has no control - he cannot start it, stop it, reverse it, speed it up, or slow it down. Time for a disintegration is measured in half-lives - the time it takes for one-half of the radioactive substance to disintegrate. The half-lives for different radioactive substances are different from one another and can vary from .001 second to 200,000 years and more.

A nuclear reaction is any process where two nuclei react or a nucleus reacts with an elementary particle to produce one or more than one nuclei. Rutherford was the first person to bring about a nuclear reaction by artificial means. In 1919 he bombarded nitrogen with alpha particles and produced an isotope of oxygen that had a mass of 17 a.m.u. This is a stable and non-radioactive isotope. The common form of oxygen has a mass of 16 a.m.u. An isotope of oxygen means that the nucleus has more or less neutrons than the common atom of the periodic table. The element is still called oxygen because it has eight protons and eight neutrons. Isotopes can be radioactive or non-radioactive.

Nuclear reactions, like chemical reactions, are accompanied by the release or absorption of energy. According to Einstein's equation, $E=mc^2$, a small mass change can yield a large energy. How large this energy can be is illustrated by the fact that one atomic mass unit is the equivalent of one billion electron volts. Thus any nuclear reaction which caused a change in the mass of the reacting substances could release enormous amounts of energy. The first indication of how vast this energy might be came in 1939 with the work of Hahn and Strassman in Germany. When they bombarded a ${}_{92}U^{235}$ nucleus with a neutron, the nucleus split - this is called fission - and the masses of the two new nuclei were about 0.2 a.m.u. less than the original nucleus. This means that about 200 million electron volts were released. This energy is about equal to that of exploding twenty tons of TNT or is about 2.5 million times the heat produced by burning the same amount of coal.

The work of Fermi <u>et al</u> in the early 1940's led to the first controlled fission. This was done under Stagg Field in Chicago on December 2, 1942. Fermi turned this reactor on at 3:25PM and off at 3:53PM, showing that a nuclear chain reaction could be started, maintained at a desired rate, and stopped at will. It takes a certain critical mass to start this fission. If the substance to be split is less than the critical size needed, no reaction will occur. If the nucleus is too large, an explosion will occur. After a neutron splits the first nucleus into two, these two are then split into four, four into eight, and so on. This is the meaning of a chain reaction.

The power of a nuclear fission was demonstrated on July 16, 1945, when the first atom bomb was exploded at a test site. Shortly thereafter the atom bomb was dropped on Hiroshima, killing over 100,000 people, but ending World War II. However, all the uses of fission are not for war. Some peaceful uses of nuclear fission are treatment of cancer, dating rocks, detecting flaws in metals, detecting tumors and circulation problems in humans, authenticating paintings, producing power, and many others.

Fission reactors yielding electricity for all to use are based on the same principal as the fossil fuel plants except the energy source is different. Heat from the energy source produces steam to turn a turbine to drive a generator to set up a current of electricity. Let us now investigate how fission can be used as this energy source.

About 99% of the Uranium found in nature is U^{238} while only about 1% is U^{235}. In order to obtain quantities of U^{235}, scientists had to separate the isotopes and it was found that chemical means could not be used to do this as isotopes of an element undergo identical chemical reactions. Therefore physical means were developed and are used. One is the diffusion method as $U^{235}F$ diffuses faster than $U^{238}F$. The other is the mass spectograph where ions are passed between the poles of a powerful electromagnet. In this case the atoms of U^{235} are deflected more than the U^{238}atoms are.

A nuclear chain reactor contains the materials that are capable of sustaining a chain reaction. Fission may occur in U^{238}, but the reaction does not set off a chain reaction. Fission also occurs in U^{235} and this also starts a chain reaction. This thus shows us the importance of using U^{235} in the reactor rather than U^{238}.

When a nucleus of U^{235} undergoes fission, from two to three neutrons are emitted at the same time and each in turn may cause the fission of another nucleus. The mass of U^{235} from which the chain reaction will be just self-sustaining is called the critical mass. In a mass of this size, about one neutron from each fission collides with another nucleus. This fission reactor uses slow-moving neutrons. The material or moderator used to slow down the neutrons is usually graphite or water.

Plutonium 239 also can undergo this controlled fission chain reaction and can be formed from the fission of the more commonly occurring U^{238}. Plutonium 239 can be used in the breeder reactor which makes use of fast neutrons. The moderator is eliminated in this cycle and the breeder reactor makes more usable fuel than it uses, therefore always supplying more fuel to generate more electricity. The U^{235} reactor does not do this. However, the Pu^{239} energy source is not as safe as U^{235} is. Let us now investigate some of the pros and cons of fission reactors themselves and the use of U^{235} versus the use of Pu^{239}.

Today we have about twenty percent of the country's electrical capacity in our fission reactors with over 100 reactors built or being built and many more at the design stage. The chairman of the Atomic Energy Commission in 1950 said that nuclear energy would give us cheap, abundant electricity. Not only does electricity cost more than gas or oil today, but it is also only half as efficient. This is one failing of the nuclear fission electrical dream. Also, we only have enough U^{235} to last us about fifty years. By that time breeder reactors and other energy sources may take over for us. However, there are some other drawbacks to nuclear power besides the cost, the efficiency, and the limit of our natural resources. Reactor safety in both construction and operation is a big problem.

Radiation leaks (some of which are now being documented by citizens with geiger counters) are serious problems. Documentation of radiation causing cancer and leukemia is readily available. Cancer of the thyroid and lungs is also evident. Chronic exposure to radiation also leads to a shortened lifespan and genetic mutations and defects which are hereditary. Exposure to radiation in nature is unavoidable and exposure to radiation through xrays et al is up to personal choice. However, leaks in a reactor could create further damaging exposure over which a worker or community resident has no control. The Atomic Energy Commission has set standards for all reactors - but are they and will they be met?

Nuclear wastes are creating another problem. What do we do with these radioactive wastes? How can we prevent them from being sabotaged? What about long-term storage of those wastes with very long (200,000 years) half-lives? How can we be sure there is no thermal pollution of water near nuclear reactors? These problems are questions that must be answered for the safety of both the population now and the populations of future generations.

Sabotage and the problems of safeguarding fissionable reactor fuel which may be used for manufacturing is much more of a problem with Plutonium 239 than with Uranium 235. It is difficult to isolate U^{235} and then make a bomb. The Pu^{239} is quite readily made into a bomb and could clearly, easily be used for the wrong means.

The hazards of Pu^{239} are also evident when discussing storage. Pu^{239} has an extremely long half-life. There are wastes from reactors and these dangerous radioactive wastes have been dumped in oceans and buried in mines. Perhaps this will be the ultimate killer pollution. No adequate long-lasting containers have been built to store these wastes effectively. Earthquakes et al also make this situation harder to solve.

Some advantages of nuclear power generators are that they emit virtually no air pollutants, mining of nuclear fuels do not disrupt the environment as much as the mining of fossil fuels does and transportation costs are low. Clearly nuclear fuels are a power source, but we must analyze carefully the pros and cons of this fuel source carefully. We also must decide what sacrifices, if any, we are willing to make for more electricity.

Controlled nuclear fusion looks like a nearly ideal source of energy. However, we must remember that coal and fission both at one time were thought to be ideal energy sources. Because we do not yet have a fusion reactor we do not know what the safety problems will be. We do know that a fusion reactor will not get out of control as a fission reactor might. It is difficult to get a fusion reaction started in the first place and anything going wrong stops the reaction. Fusion requires that two nuclei come together or fuse, enabling the extremely powerful intranuclear forces to come into play. The uncontrolled fusion reaction is the hydrogen bomb. Fusion occurs in the stars. The fusing of deuterium and tritium is the goal of scientists now for a fusion reactor. A model of this is being made at M.I.T. Deuterium is very plentiful in supply in sea water.

Tritium is not in plentiful supply. Therefore, the next goal would be a fusion reactor using deuterium and deuterium.

Three conditions must be achieved at one time in a fusion reactor for it to work. These are attaining a temperature of about 100 million degrees, creating a vacuum which insures frequent collisions of nuclei, and a confinement time long enough for the process to yield much energy. A big problem is finding a container in which these reactions can take place.

Fission and fusion are possible energy sources for us and the pros and cons of each will yield lively discussions in your class. The September, 1973, copy of Resources published by Resources for the Future, Inc., has a good article, "The Faustian Bargain," which can be read to the students to both provide information and stimulate discussion.

MINI UNIT #8

ENERGY SOURCES OF THE FUTURE

Objectives and possible quiz questions:

Students should be able to answer the following questions:

1. How can animal and agriculture wastes be of value?
2. How is St.Louis disposing of its trash?
3. List two advantages and one disadvantage of windpower.
4. What is hydroelectric power? List two advantages and one disadvantage of hydroelectric power.
5. List one advantage and two disadvantages of geothermal energy.
6. Name one technical problem that remains to be solved in order to use fusion nuclear energy.
7. List three ways in which solar energy is already being used.

Projects due:

Any chosen by the teacher.

Class Discussion Questions:

1. Is there such a thing as free energy or do all forms of energy have their advantages and disadvantages?
2. What forms of energy do you feel will be used in the future?

Background material is on following pages.

ENERGY SOURCES OF THE FUTURE

All of our present fuels will be in greater production in the next twenty-five years - oil, coal, natural gas, and nuclear. Of these, nuclear has the potential for increasing the most. Wood does not seem to be an energy source of the future. Its value as a raw material is too great to burn it as a fuel.

One good source for the future that is presently being mostly ignored is the waste of animals and agriculture. These wastes may either be burned as fuel or converted to fertilizer. Feed and food supplements can also come from agricultural wastes. Bagasse, a fibrous by-product of the sugar cane industry, can be used in the manufacture of paper.

Animal wastes now pollute air and water and we consider them a nuisance. But they are a valuable resource. As a fertilizer they could supply approximately 10% of our fertilizer needs. Converted to methane gas by anaerobic digestion they could supply enough methane to be equal to one-half of our present natural gas consumption.

St.Louis, by 1977, will burn all of its trash for the city to provide approximately 15% of its electricity needs. Numerous cities in Europe are already doing this. Disposing of trash is now a big problem in this country. We can turn the problem into an energy solution. Plastics present a problem in burning trash, however, since they give off poisonous gases.

Windpower has been used for years, but had dropped in popularity until just recently. Now, because wind power is non-polluting, renewable, and non-depletable, it is receiving more attention as a source of electricity. The disadvantages are that the wind is intermittent and unreliable. Therefore, a back-up source is needed or else some sort of storage facility such as a battery or fuel cell must be used. Geographical sites that have more wind would be the best places for wind mills.

Tidal electric power depends on the two-directional flow of water with the tides coming in and going out. Where this occurs with a substantial difference in water level in a partially enclosed basin and is controlled by a dam, the electricity production potential is great. Unfortunately, with present technology, not many geographical sites fulfull these requirements. Therefore the projected capacity for the world's electricity supply is only 2%. France installed a tidal plant in 1966. The Bay of Fundy is being considered as a site (the water level difference between high and low tides is approximately 50 feet!) . Russia is also looking into sites.

Hydroelectric power plants supply about 15% electricity in the U.S., much of it in the northwest. Water falls at controlled rates through a dam, spinning turbines which drive generators to produce electricity.

By the year 2000, hydroelectric power will probably have fallen to 7% of our total output of electricity. However, for the world as a whole, it is a great power source and could provide ten times what has been developed as of now. Hydroelectric power is clean, inexpensive, and requires no mining or processing of fuels. However, the reservoir or lake that forms behind the dam usually covers choice farm land, and eventually (in a century) the reservoir will fill with the silt carried by the river.

Geothermal energy is energy that comes from hot water or hot rocks beneath the earth's surface. The heat is produced by the decay of radioactive materials in the crust and mantle of the earth. The first production of geothermal electricity was in Italy in 1904. New Zealand, the U.S.S.R., Japan, Mexico, and the U.S. have plants in operation for the production of electricity. Iceland uses geothermal energy for space and water heating. They grow bananas in greenhouses warmed by geothermal heat! Steam, such as from geysers or underground fields, drives turbines to produce electricity, a method which is very inexpensive. However, because of the very high mineral content of the water, the machinery is easily harmed. It is difficult to safely dispose of the highly salty waste water. The process is also inefficient. In addition, drilling into the earth possibly may trigger earthquakes. Geothermal energy is a depletable resource, having a lifetime of about fifty years per site.

Breeder reactors may fill the energy gap in the intermediate future. In the breeder, more fuel is produced than is used up, thereby greatly extending our nuclear fuel reserves. However, the materials handled are highly radioactive, and absolute safety has not yet been achieved in the reactor.

Fusion is a potentially fantastic energy source of the future, but probably will not be available for at least twenty-five years, if at all. In fusion, atoms of light elements are joined together to form helium and a great release of energy. The main source of fuel (deuterium which is heavy hydrogen) is found abundantly in sea water. Furthermore, most of the wastes are not radioactive as in the fission process. Enormous technical problems must be solved, however, since temperatures of 100 millions degrees must be reached at high enough density and for a long enough period of time for reaction to occur.

For solar energy, much of the knowledge and techniques already exist, but much research needs yet to be done to bring costs down to an affordable level. Certainly much solar energy is available. But the energy is dilute and must be collected over large areas. Also it is intermittent and therefore must be stored. Solar energy has many advantages - it burns no fuel, does not pollute, is readily available, and is a renewable source.

Solar energy is currently being used for small-scale operations such as drying foods, distillation, water heating (Japan), evaporation ponds, refrigeration, ovens, and heating of homes. Since 30% of the world's energy is used for space heating, this last use becomes very important.

Already several solar houses have been built. These houses have collectors on the roof which transfer heat into water or air, which is then carried to a bin of water or gravel for storage. The heat is then circulated to the living area when needed. These houses are built with adequate insulation, thermal pane windows, and careful construction. The roof is at the proper angle to pick up the maximum amount of energy from the sun. Storage batteries are used to provide electricity on cloudy days, and a supplementary heating system is usually used for the coldest months.

Satellites orbiting the earth have been proposed to collect solar energy on a large scale. These have the advantage of being beyond the reach of clouds. It has also been proposed that large areas of desert be covered with solar energy collectors. Perhaps the energy collected in such a system could be converted to hydrogen and then shipped to where needed.

Perhaps even with solar energy there will be drawbacks. We might upset the earth's heat balance by altering the distribution of solar energy on earth.

There are many energy sources that the earth may draw upon in the future. Hopefully diversity is the key to survival.

MINI UNIT #9

OUR FUTURE - THE PROBLEM OF THE NEXT 2-4 YEARS, THE MEDIUM TEAM, AND THE DISTANT FUTURE

Objectives and possible quiz questions:

Students should be able to answer the following questions:

1. List ten ways that the U.S. might increase its supply of fuel, or lessen the demand for fuel.
2. What is meant by historical growth? What would we have to do with our energy sources to obtain historical growth?
3. What is meant by "technical fix" growth? What would we have to do with our energy sources to obtain "technical fix" growth?
4. What is meant by zero growth in energy? List four changes that this would make in our present society.
5. Which scenario do you see as the best one for the future?

Projects due:

Any chosen by the teacher.

Class Discussion Questions:

Suppose you are a member of Congress. Write and discuss a law that will reduce energy consumption and yet be fair to all Americans. Be sure to consider all implications of your law, such as rising unemployment. Also, state how your law will be enforced.

Background material is on following pages.

OUR FUTURE - THE PROBLEM OF THE NEXT 2-4 YEARS, THE MEDIUM TEAM, AND THE DISTANT FUTURE

The United States has suddenly become aware of its energy vulnerableness. The cheap never ending supply from the rest of the world is no longer cheap and may end any time at the whim of the producer. We find ourselves in a position where we cannot supply the enormous amount of energy we are accustomed to.

Even if the supply from the Arabs is not interrupted, we will soon bankrupt ourselves if we continue to buy the amounts we have in the past. Once thought impossible, the collapse of capitolism is now being predicted.

Surely a country as vigorous and diversified as ours can rise to the challenge and produce more energy from present sources and expand the number of sources. Looking at possibilities, we find that we can do the following:

1. Increase our production of coal - both strip and deep mining.
2. Build more nuclear plants.
3. Build the Alaskan pipeline.
4. Dig for off-shore oil.
5. Use secondary and tertiary methods for getting more oil out of present wells.
6. Dig more wells.
7. Get shale oil.
8. Use solar and geothermal and wind and tidal power.
9. Use breeder reactors.
10. Use fusion.
11. Get a more efficient car engine.
12. Drive smaller cars.
13. Conserve.

With so many options there should be no problem at all. But only the last two options are available immediately. It takes three to five years to plan and carry out a major expansion of off-shore oil production, and eight to ten years to construct a nuclear power plant. Alaska pipeline will not be done for at least three years. Three to five years are needed to open a new underground mine. Two to three years are needed to build strip mine equipment. Rails can only accomodate at present an 8% increase in hauling. Breeders are ten years or more in the future. Solar and fusion are twenty-five years or more.

Therefore, in the short term the energy gap must be bridged by lowering consumption. Consumers can make technical improvements - insulation, storm windows, smaller cars, etc. They can also use less energy.

At the same time, all of our options for the future should be started immediately. We should start to plan. What kind of a future do we want? We should know where we are going and this should help us decide how to get there.

The Ford Foundation has made an extensive investigation into our future energy choices. They have selected arbitrarily three different scenarios of future energy use.

I. <u>Historical growth</u>, with our use of energy doubling every twenty years. To do this we would need very aggressive development of every possible supply - oil, gas, coal, shale, nuclear. It would be difficult to do without imports. As an example of how hard we would have to press development: by the year 2000 we would need sixty times as many nuclear plants as we now have. All continental shelves would have to be developed for oil. Many more refineries would be needed, many more power plants, many transmission lines. Pollution and destruction of land, together with prices would create tremendous problems.

II. <u>Technical fix</u> - a growth rate, about half that of the historical growth. In this, efficiency rather than increased supply will be the important part of energy policy. The standard of living would not be reduced, and our life style would not be significantly changed.

All of the efficiencies mentioned earlier would be utilized - better building design, use of heat pumps, increased use of solar heating, heat recovery systems for industry, smaller cars, recycling, shifting from trucks to rails, using wastematerials, etc.

1. What the government can do: We would need a "Truth in Energy Law" which would require labeling by the manufacturer to clearly spell out average energy use and operating costs for everything we buy.

2. Laws, which through tax advantages and regulated freight rates currently favor new materials, would have to change to favor recycled materials.

3. Congress will have to support mass transit and rails, rather than the current practice of subsidizing air and highway.

4. Federal money now is being used to develop energy supplies, but it will have to be spent more on consumption of energy- and ways to live.

5. There could be an excise tax on energy. e.g. If the use of a particular form of energy causes pollution, the excise tax would be enough to take care of that pollution.

6. For cars, a law could state that all cars have to get twenty-five miles per gallon. Or, if a car did get twenty-five miles per gallon, no tax would be put on that car. But for every mile per gallon under twenty-five that the car got, a penalty tax would be imposed.

Under the technical fix plan, we would not have to press development of suppies as much. We would have to increase supplies, but we would be allowed some leeway in which supplies we increase significantly. We could have alot of nuclear power, thus allowing us to go easy on some other resources. Or else we could phase out nuclear altogether by greatly increasing, say, shale oil and coal.

III. A zero energy growth (ZEG) scenario. Many people feel that our planet is rapidly approaching its limits to growth. Sooner or later, (and it appears ever sooner) there will be too many people, too little food, too much pollution, for us to survive. Either that or we will run out of raw materials. In addition, as we grow and become more affluent just to handle this growth, we become more inhumane. E.g. we are increasingly a part of many number systems - Social Security, zip code, etc. What would ZEG be like? For the next fifteen years, it would be approximately the same as the technical fix scenario, and then there would be zero growth thereafter. Economic activity would not be stagnant. Today we use energy recklessly. We would have to change where we are careful with our energy resources and this will cause some changes. Cities will be redesigned, as will transportation systems. Energy-intensive industries (e.g. plastics) would be on the decline. There would be more growth in the service sector - education, medicine, government, etc., a direction we are already headed in (60% of our present work force.) We would not have a Spartan existence, but rather by 2000 we would have ten percent more energy per person than we now use - and more efficiently used energy at that. We would have appliances such as air conditioners and dishwashers. Electronic equipment, which uses little electricity would be more abundant.

However - there would be an end to the "more is better" philosophy. Instead we would have "enough is best!" Changes: New communities would be designed where homes are close to jobs, stores, and schools. Most people would need to travel only by foot, bicycle, or mass transit (Seabrook Farms in New Jersey.) There could be suburbs to core cities, connected by rapid mass-transit links. Fast rail service would link cities up to 400 to 500 miles apart. Planes would be used mainly only for long distances. The trend would be to multi-family housing, since these use less energy than single family dwellings. Or perhaps single dwellings would be partially underground to save fuel. Electricity could be produced for a certain small sized area, with all waste heat being used to heat homes or provide energy for industries. Thus there could be little waste. All products would be designed to last, as well as being made easy to recycle. As much use as possible would be made of solar energy, wind, wastes, etc. In industry, warehouses and factories could be built underground for a vast saving of energy - (they stay cool in summer, warm in winter. They are not subject to damage from storms. They are more stable.) Energy intensive industries - plastics, fertilizers - could operate perhaps in the Arab countries, where energy is cheap and abundant. We could place more emphasis on agriculture, electronics, and high technology products, which we could export. We could import the others. There should be a marked decrease in plastics used for packaging and in automation.

If these changes take place over a period of ten to fifteen years, and the government carefully watches employment, retraining workers where necessary, the transition should be easily made.

Unfortunately at present our government is geared to an historical growth scenario. Hopefully they will be educated in time.

MINI UNIT #10

SUMMING IT ALL UP - DELAWARE AND U.S. POLICY

Objectives and possible quiz questions:

Students should be able to answer the following questions:

1. Why is it important to have a plan for future energy use?
2. What is Delaware's Coastal Zoning Law?

Class Discussion Questions:

1. Do you think that rationing or a tax on imported oil would be a better way of cutting back on the use of oil?

2. Discuss the position of the U.S. with respect to the world problems of food and energy.

Projects due:

Second article and second project may be due now.

Background material is on following pages.

MINI UNIT #10

SUMMING IT ALL UP - DELAWARE AND U.S. POLICY

We are in the middle of an energy dilemma - a crisis, if you wish to call it that.

At the moment, our country is not producing all of the energy we need. Because of drastically increased prices of foreign oil, we find that we will have serious economic problems if we continue to import so much oil. We do have resources at home that we can develop, but it takes time to develop them, and thus for the short term we have shortages. Furthermore there are problems involved with each resource that we choose to use - whether it be environmental, or monetary, or genetic (in the case of nuclear.) Therefore, it is most important that we take a long hard look at where we are going. What do we want for the future? How much additional energy do we really want to use? It is imperative that we as a people have a plan. This plan must be decided upon soon. One of the causes of our present dilemma is that no plan has existed in the past. We have allowed growth to take place at any rate that anyone wished. Once we have a plan and can decide fairly accurately what our energy needs will be, we can then decide what energy sources we wish to develop, and at what rate. We should plan for the near future and the distant future. The research and development must come now, before our fossil fuels run out.

We have roles - as citizens of Delaware, the U.S., and the world. Let us examine each.

Delaware has a large coastal area that is desired by industry. The nearby water is valuable for transportation and as a cooling agent for industrial processes. At present we have one oil refinery (Getty) on the coast, and numerous other industries. The coast of Delaware provides recreation - our second biggest moneymaker in the state - and the coastal marsh areas are the breeding grounds for much of ocean life. Delaware has passed a Coastal Zoning Law that says that we want to protect a two mile (approximately) wide strip of land along the coast. We will not allow oil refineries, steel or paper mills or chemical complexes in this strip. But smaller businesses are welcome as long as a special board appointed by the Governor approves. Shell Oil Company is fighting this law because they want to build a refinery somewhat south of the Getty refinery. Some people feel that in the energy crunch we should provide space for more refineries. Others feel that Delaware is already doing more than its share by having Getty. At any rate, we as citizens have to decide what Delaware will do. Our life styles may have much to do with what Delaware must do. Also at this time the U.S. government is deciding whether we should explore for oil off our coasts.

As for U.S. policy, the government at long last, has recognized that we have an energy problem. They realize that we must take steps to conserve energy. The problem is how do we conserve it? The president has suggested one way - to put a $3.00 tax per barrel on imported oil. Many people have reacted negatively to this suggestion. Some members of Congress want rationing instead, saying that the $3.00 tax would be inflationary. Many people do not want rationing either. We must do something, but it is going to be difficult to get people to agree on what to do. What do you think is the best solution?

For the long term, the U.S. will have to make plans, as referred to earlier, about our future. Again, we as citizens should have much to say about our energy needs. At the present time, the government is committed to a highly nuclear future. President Ford, in his 1975 state of the Union message, wants two hundred additional nuclear plants. Most of the money spent for research goes to nuclear energy.

As world citizens, we are only about 1/16th of the world's population. We are members of the world community, whether we like it or not. We cannot exist by ourselves. Even if we become energy self-sufficient, there are still many raw materials necessary to us that we have to import. We have found with oil that we are not invincible. Therefore our policies have to be those in which we work together with the rest of the world.

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Most books are available in paperback.

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FIELDTRIPS

Conowingo Dam Hydroelectric Plant
Conowingo, Maryland - 301-457-4161

Delmarva Power Edgemoor Plant
Wilmington, Delaware - 302-429-3594

Peachbottom Nuclear Power Plant
York County, Pennsylvania - 717-456-5101

Second Sun Nuclear Power Plant
Salem, New Jersey - 609-935-5500

Solar One Solar House - University of Delaware
Newark, Delaware - 302-738-8481

FILMS

The following films are excellent and can be rented from:

Films, Incroporated
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The cost is $22.00 to $30.00 each. If you can afford only one film of the series, we recommend the one on "Future Fuels". All films are current and give quite complete information on these topics:

"Coal"
"Oil"
"Natural Gas"
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MAGAZINES

Current issues of the starred(*) magazines are particularly worthwhile:

American Home
Consumer Reports
DuPont Context
* Mechanical Engineering
Natural History
* Newspapers: New York Times, News Journal, and Philadelphia Bulletin
* Newsweek

MAGAZINES - (Continued)

- * Popular Science
- Resources for the Future, Incorporated
- Science - American Association for the Advancement of Science
- * Science News
- * Technology Review (M.I.T.)

SPEAKERS AND MATERIALS

DART on "Mass Transportation"
Wilmington, Delaware - 302-655-3381

Delmarva Power and Light Company on "Advantage of Nuclear Energy"
Wilmington, Delaware - 302-429-3594

Coalition for Nuclear Power Plant Postponement and Sierra Club on "Disadvantages of Nuclear Energy"
Wilmington, Delaware - 302-652-2456

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